RADIATION FROM RADIOISOTOPES

I. Significance / Credibility as an Agent of Terrorism

Radioisotopes are unstable chemicals, whose radioactivity is measured by the number of atoms disintegrating per unit time. A disintegrating atom can emit a beta particle, an alpha particle, a gamma or x- ray, or some combination, which disrupts molecules in living cells, and deposits energy in tissues, causing damage.

Radioisotopes have a number of beneficial uses, such as medical imaging, diagnosing disease and treating cancer, generating electricity via nuclear power, conducting biomedical research and development, industrial uses such as measuring material thickness and density, and increasingly, for homeland security purposes such as imaging of shipping containers at Ports of Entry to the U.S.

Radiation has been described as having a "higher perceived risk" than some other potential terror agents due to a number of factors: radiation is a source of public dread (nuclear weapons, nuclear power), is not observable, is unknown to the exposed, chronic effects are insidious, effects are not equitable, exposure is involuntary, consequences are potentially fatal, and exposure to parents presents potential genetic risk to future generations. High-risk groups for psychosocial harm in a radiological terror scenario are: children, mothers with young children, pregnant women, emergency/clean-up workers, and their families.

Certain radioisotopes are considered more likely to be of interest as agents of terror, due to their high-energy emissions, long half-life (duration of radioactive emissions), and/or the relatively large number of sources distributed throughout medical, academic, industrial and research facilities. "Isotopes of greatest concern" were identified in 2003 by the federal government based on relative dose impacts & potential for dispersion (material index) and relative attractiveness for access ie. number of facilities with greater than threshold values & level of facility security (attractiveness index). See Attachment A.

In addition, a review of radioactive material facilities located in Delaware was conducted in the fall of 2003, resulting in a prioritized list of radioisotopes of concern, based on the following factors: principal radioactive emission energy (alpha or beta particles, gamma or x-rays), degree of penetrating ability, and physical half-life. These criteria were selected to address potential for personal injury, contamination of facilities, and business disruption if materials legitimately possessed or stored in Delaware were to be used for terrorism.

"Characteristics of Certain Isotopes of Greatest Concern"
Radiological Dispersal Devices:
Report to the Nuclear Regulatory Commission and the Secretary of Energy,
By the DOE/NRC Interagency Working Group on RDD's
May 2003

Isotope	Common Use	Description
Am-241 (Americium)	Measurement instruments, eg. well logging instruments and gauges, smoke detectors	Sources are typically small to moderate in physical size and radiological emission (up to 1 inch in diameter, 6-inches long, and tens of millicuries to tens of curies in strength); smoke detectors use microcurie quantities. In neutron sources the Am-241 is typically mixed with beryllium oxide, which is a toxic substance; double-encapsulated in stainless steel holders; and used for a variety of industrial assay applications. Thousands of these sources are in use.
Cs-137 (Cesium)	Medical imaging, food/other irradiation, gauges	Found in sealed portable sources and in large irradiation facilities. The sealed sources are often found as cesium chloride, a form of particular concern for RDD use.
Pu-238 (Plutonium)	Medical devices and measurement instruments	In the past used as a heat source for pacemakers, an application that was phased out in the early 1970's. also used as thermal-electric generator heat source where it is contained as an oxide in stainless steel or other containers. As with Am-241 and Pu-239, and unlike the gamma emitters, a great deal of shielding is not required in application.
Sr-90 (Strontium)	Heat source for thermal-electric generators and sealed sources	Used in large quantities in heavily shielded configurations.
Po-210 (Polonium)	Static eliminators	Typically found as metal foils.
Co-60 (Cobalt)	Food/other irradiation and radiography	Typically cast as metal rods, or pins, several to dozens of which are combined in a holder to provide desired radiation intensity. Storage requires heavy shielding , typically in large facility.
Ir-192 (Iridium)	Gamma source used for mobile and fixed radiography applications.	Used in many fixed and mobile irradiation applications, these sources are found in instruments used for weld inspections and other industrial applications. The mobile application of these sources and availability make them a particular concern.
Pu-239 (Plutonium)	Alpha or neutron source, typically used in research	Used in research facilities, these sources are generally small because significant quantities of Pu-239 are tightly regulated because of weapons potential.
Cm-244 (Curium) Or Cf-252 (Californium)	Neutron source used in research and measuring instruments	Sources are small, and those in instruments are shielded.

Agent Detection & Identification During Emergencies
Survey of DNREC & DPH Capabilities in Field and Labs
11/05/2003

RADIOLOGICAL AGENTS

Select Radioisotopes	Principal forms of radioactive emission: Alpha (A), Beta (B), or Gamma (G)	1. Stored, Used or Transported in DE	2. Relative Threat Level: High/Med/Low
Cobalt-60	B, G	X	High
Cesium-137	B, G	X	High
Iridium-192	B, G	X	High
Americium-241	A, G	X	Med
Phosphorus-32	B	X	High
Iodine-123	G	X	Low
Iodine-131	B, G	X	High
Technetium-99m	G	X	Low
Tritium (Hydrogen-3)	B	X	Low
Carbon-14	B	X	Low
Sodium-24	B, G	X	Med
Sulphur-35	B	X	Low
Strontium-85	G	X	Low
Uranium-238	A, G	X	Med

- **Select Radioisotopes** represent a small proportion of those commercially available, and were selected based on common usage in medicine, education, research and industry.
- **Relative Threat Level** determined based on combination of principal radioactive emission energy, degree of penetrating ability, and physical half-life. Criteria were chosen to address potential for personal injury, business disruption and/or contamination of property.

II. Dispersion Methodologies

Prior to September 11, 2001, approaches to controlling radioactive materials were generally oriented to beneficial uses, and protecting workers and the public from unnecessary radiation dose. However, the nation's concerns regarding the use of radioactive materials for a malevolent act have been heightened, and many actions have been taken to strengthen safeguards to ensure the security and authorized use of materials.

Of particular concern has been the nation's ability to protect inventories of radioactive materials that could be used in a radiological dispersal device (RDD), which could incite terror, result in deaths and/or injuries, and disrupt operations in facilities or areas where the RDD is exploded. An RDD is a device combining conventional explosive material for detonation, to effect dispersal of radioactive material over an area. Lethality and serious injury would affect those in the immediate vicinity of the blast, but probability of delivering sufficient radiation dose to create serious injury is low. RDD's have been described as "weapons of mass disruption", because they are unlikely to result in many deaths, but are likely to cause panic, spread radioactive contamination requiring significant clean-up, and potentially disrupt operations for an extended period of time. The economic impact of such disruption would be considerable if an RDD were exploded in a major transportation hub, entertainment venue or other mass gathering.

A second methodology for dispersing radiation from radioisotopes would be an improvised nuclear device (IND). Such a device would utilize fissile radioactive material to initiate a nuclear chain reaction (explosion associated with a nuclear bomb). Such a device could be used as a weapon of mass destruction, that would result in many deaths, many cases of acute radiation syndrome, and ultimately, for many years following the explosion, elevated incidence rates and mortality from radiation-related cancers among survivors, as well as increased incidence of birth defects, cancer and/or mental retardation for offspring exposed *in utero*.

A third methodology is dispersing radiation from radioisotopes surreptitiously so that recognition of the contamination event might occur sometime later, after significant spread of the radioactive material. Examples are introducing radioactive particulates or aerosols in the ventilation intake of a building or other facility (ie. transportation hub), or dispersing an aerosol from a vehicle (airplane). Factors that make this scenario less likely include: very low probability of lethality or serious injury, technology needed to aerosolize radioisotopes (make them available for inhalation) is technology/cost-intensive, and quantity of aerosolized radioisotope used would limit the magnitude of exposure (area affected is dependent on quantity of radioisotope available).

III. Major Routes of Exposure

A. External Irradiation

Radiation dose delivered to the skin from external irradiation. External irradiation can occur to an individual located in close proximity to a radioactive source emitting high energy, highly penetrating radiation (eg. gamma or x-rays or neutrons). External irradiation can also occur to an individual coming into contact with a radioactive plume (airborne release of particulate or gaseous radioactive material).

B. Inhalation

Radiation dose can be delivered and internalized by breathing in air containing radioactive gases or particulates, such as a radioactive plume. Inhalation exposure can also occur by inspiring radioactive residue deposited on surfaces, and then re-suspended in air.

C. Ingestion

Radiation dose delivered to the gastrointestional tract by ingesting radioactive material, as residue or contamination of crops/foodstuff or as contamination from radioactive particulate matter deposited on surfaces (ie. Food eaten with contaminated hands).

D. Internalization

Radioactive material may be inhaled, either as gases or particulates. Some may be ingested, from mouth contamination, ciliary movement in the bronchial system that moves particulates to the mouth, or the eating and drinking of contaminated food. In addition, radioactive shrapnel from the destruction of a sealed source of radioactive material of RDD can become embedded in a wound. Radioisotopes that deliver radiation dose while internalized are considered to be incorporated. Medical treatment to reduce residence time, bind or compete with radioisotopes and/or encourage excretion is called decorporation.

IV. Medical Treatment/Dose Reduction

Various pharmacologic mechanisms can be utilized to reduce internal radiation dose, and effect radioisotope decorporation. Medical factsheets are attached to provide an overview of medical treatment and/or dose reduction techniques.

V. Field Operations

A. Exposure Control/Containment

Persons exposed to only external irradiation pose little risk of secondary contamination to others. However, clothing or skin contaminated with dust or particulate matter can become a source of radiation dose to emergency or medical personnel, or contaminate the vicinity of the exposed person (eg. Emergency Room). An area may be designated as unsafe due to the presence of airborne radioactive particulate or gases, which can be affected by wind speed, wind direction, and other factors. Boundaries will be established by the emergency response team and subsequent instructions will be provided.

B. Dosimetry Tracking

Emergency workers with potential for radiation exposure are provided dosimeters to measure and record their radiation dose. DEMA is the lead agency with operational responsibility for keeping records of radiation dose. DPH ORC is the lead agency for technical assessment of dose considerations, and making protective action recommendations for radiation dose limits.

C. Personal Protective Equipment (PPE)

Level of Personal Protective Equipment (PPE) to be used by emergency workers and others is defined by DEMA plans and State Emergency Response Team (SERT) procedures.

Rescuers entering restricted radiation zones should be trained and appropriately attired before entering the controlled area. If the proper equipment is not available, or if rescuers have not been trained in its use, assistance should be obtained from a local or regional HAZMAT team or other properly equipped response organization.

D. Decontamination

Decontamination of workers and equipment to be handled by State SERT team, or Delaware National Guard field monitoring teams, per DEMA plans.

E. Disposal of Waste

Disposition of radioactive waste generated in an emergency event to be handled per DEMA plans.

VI. Communications

Event/Situation Notification

Notification from SERT

- For large chemical events, SERT (State Emergency Response Team) notification and communication process will take place.
- Response from DPH will utilize established DEMA or SERT communications - notifications systems.
- The DPH representative on SERT (usually the DPH Toxicologist) responds to SERT Level 2 and 3 events, with parallel notification to the DPH Radiation Control Program Director, if radioactive materials are suspected. The DPH Toxicologist can respond to Level 1 when requested by the on scene Officer in Charge. The DPH on scene representative will inform the Directors Office or Duty officer of the situation. **In all cases, this and those listed below, The DPH PIO will handle all communication with the media and public.** Public education activities will be coordinated through a Risk Communication Committee consisting of the PIO's of DHSS, DPH, DEMA, DSP and other partners.

Other means of Notification

- Direct Citizen Call to ORC - If the presence of a material suspected to be radioactive is reported directly to the DPH by a citizen, the call is channeled directly to ORC. These calls are typically channeled to DNREC/Law Enforcement. If asked/directed, ORC may respond jointly with DNREC/Law Enforcement as deemed appropriate. ORC will notify the Director's Office.
- Direct DNREC Call to ORC - If notified by DNREC that a suspicious material is being investigated and ORC assistance is being requested, ORC will notify the Director's Office.
- The DPH Health Alert Network (HAN) will serve as the primary communication network for DPH with the Delaware Healthcare Association, emergency management, and emergency response communities.

VII. Forms

VIII. Resources

IX. Reporting

As per SERT process, results of tests will be shared with on scene entities. In addition, the DPH on scene representative will inform the Director's Office/Duty Officer/SHOC as appropriate. Further release of the results will be authorized only by the SHO.

For other notifications and responses (non-SERT) the ORC will report its findings to the Director's office/Duty Officer/SHOC. The Directors Office/DO/SHOC will be responsible to contact other agencies/branches as appropriate.